Analysis of Jewelry Design Based on Computer Graphics Simulation Technology

Wei Kaixuan and Gulimila AiNi

Xinjiang Teacher's College, XinJiang WuLuMuQi 830043, China

Abstract

Firstly, through the analysis of traditional processing mode of jewelry industry, the reason that influences or restricts the production and development of enterprises is obtained. Combined with the practical experience in scientific research, a production model taking computer technology as the core is proposed, and then the proposed model is compared with the traditional model on the advantages and tested in practical production, and achieved certain results. This study combines the computer aided design and rapid prototyping technology in the fields of computer technology with actual production requirement, and realizes the "concurrent engineering" from the "product development" to "product promotion", further to "product production" in jewelry industry chain, improving the production efficiency and achieving diversity development of business.

Keywords: Jewelry; Rapid prototyping; Computer processing; Simultaneous engineering

1. Introduction

Along with the increasing popularization and rapid development of computer technology, the depth and breadth of the application of computer aided technology in various fields has been extended and expanded. Jewelry production and processing industry is no exception, from the aided design means in the research and development process including the initial collection of design material, collation, 2D computer-aided design to 3D computer-aided design, simulation model design, display design, post processing of rendering research, gradually evolved into the fast and precise manufacturing method in the production process. At present, in the field of jewelry production and processing, the cutting-edge technologies of computer aided application mainly include the simulation of 3D design, style display design and high precision rapid prototyping technology. Combined with practical production, teaching and research practice, this paper conducts research on application of computer aided technology in jewelry production and processing and according to the actual production needs in the jewelry industry, designs a workable and production and application model with a certain prospect.

2. Design Model

2.1. Application Model of Computer Technology in Jewelry Production and Processing

The development of computer aided design and rapid prototyping technology in Jewelry industry is bound to realize as far as possible the synchronization of the stages including research, promotion and production and improve efficiency; at the same time through the synchronization to realize the diversification of production. Figure 1 shows the application model of computer technology in production and processing of jewelry,

which is obtained by the author through visiting enterprises and participating in the practice. The model is divided into product research development and product promotion and product production in three steps. It is not difficult to see that the synchronization realized in the production model includes two aspects, one is within the same stage and other is the entire production process chain. The synchronization within the same stage includes that product research and development could achieve three simultaneous engineering, rapid prototyping plate, database model construction and simulation show; product promotion designs 6 links and they are independent but also connected, achieving 9 concurrent engineering; product production could achieve 3 concurrent engineering [1].
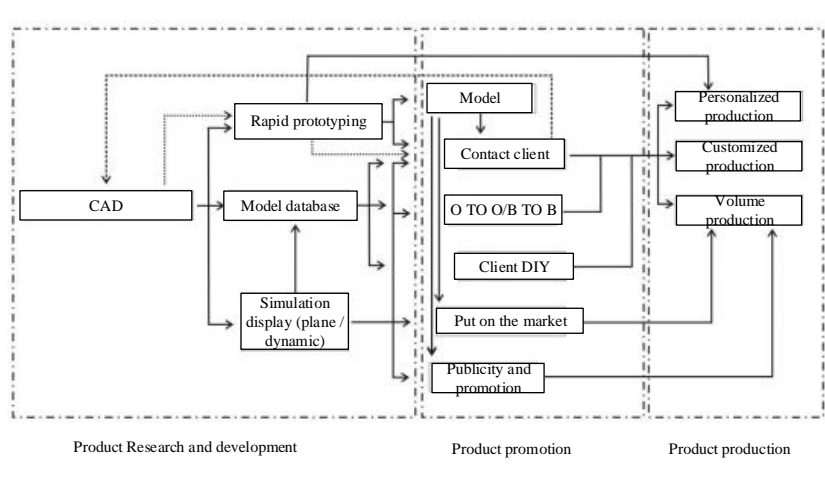

Figure 1. Application Model of Computer Technology in Jewelry Production and Processing

2.2. Model design process and Design Research

The product research and development in this design model (shown in figure. 2) is the original stage of the entire model, including 3D modeling and rapid prototyping production of model (wax model by spraying wax and printing or resin version by resin light Solidification or Gold model by CNC engraving and milling Edition) and simulation display (plane effect show or plane wearing effect simulation display or dynamic interactive animation display etc.); Product promotion includes online, offline, soft media, and hard media and so on. They are both independent and have progressive relationship to achieve a number of synchronization and diversity promotion; Product production contains personalized processing, private customization and mass production to meet all production and processing requirements [2].
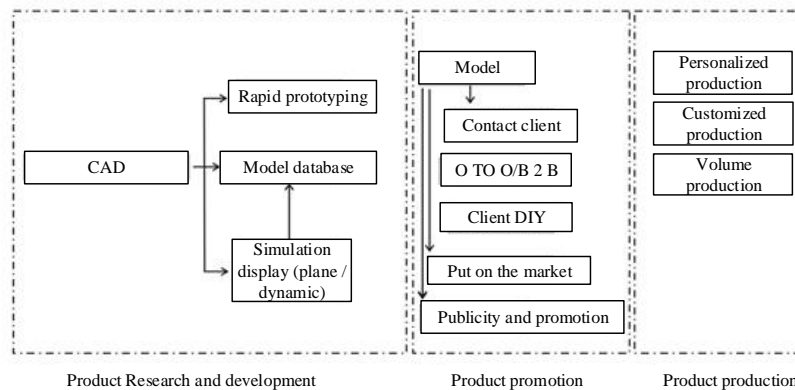

Figure 2. Basic Structure of Model

3. Color and the Performance of Metal light

3.1. Color Space Performance

In the process of jewelry design, in order to make matching of jewelry color more coordinate, it needs the comparison of specific color space, and finally the best color matching could be chosen [3].

(1) Contrast processing could make the light more bright and the shadows more dark. Completion method: take the average of brightness as the basis, and increase the larger color value, decrease the smaller color value. Method to take the middle value: i: fixed as 127; ii: the average value of all pixels of each color.

Calculation formula：V=127+(V'-127)*(1+d)

Wherein V represents the adjusted color value, V' represents the original color value, D represents the contrast adjustment coefficient, and -1<=d<=1.

(2) Color tone processing. Color tone describes the percentage of primary colors in pure color, and its value is 0~360, seen in figure 3.
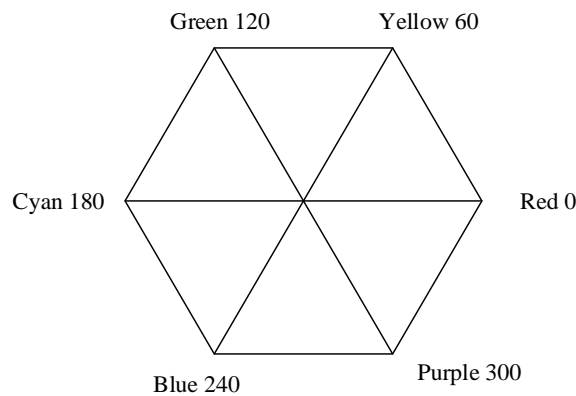

Figure 3. Primary Color Model of Tone

Calculation formula：

$$H=\begin{cases} 0 & R=G=B \\ 60(G-B)/(R-\min(G,B)) & R=\max(R,G,B) \\ 120+60(B-R)/(G-\min(R,B)) & G=\max(R,G,B) \\ 240+90(R-G)/(B-\min(R,G)) & B=\max(R,G,B) \end{cases}$$

If H<0, H=H+360

3.2. Realization Algorithm of Color Space Transformation

In the transformation of color space, the algorithms commonly used include USM sharpening, Canny edge detection and Gauss algorithm.

(1) USM sharpening algorithm. The principle is that the radius is the radius of the Gauss blur. In the calculation, first obtain the Gauss template g (x, y), and according to

the template conduct Gauss fuzzy disposal to the original image, so as to get a new numerical value blur-f (x, y).

Then calculate the numerical difference diffcrent-f (x, y) of the color values of the corresponding pixel points in the initial image and the fuzzy image. Compare in accordance with the threshold comparison and numerical difference, when the condition is satisfied, replace the numerical value in the original image with a new color, if the condition is not satisfied, the original value does not change [4].

(2) Adaptive Canny edge detection. The three indicators of Canny edge detection are high positioning accuracy, high signal-to-noise ratio, single edge response criteria. The main testing process is as follows:

1 Gauss smoothed image

When using the Canny algorithm, Gauss function is set as G (x, y):

$$G(x,y) = \frac{1}{2\pi\sigma^2} exp\left(-\frac{x^2+y^2}{2\sigma^2}\right)$$

Gradient vector:

$$\nabla G = \begin{bmatrix} \partial G/\partial x \\ \partial G/\partial y \end{bmatrix}$$

2 Calculation of the direction and magnitude of the gradient

In the past Canny algorithm, assume that the partial derivative GX[i, j] in the direction of (x, y) and GY are respectively:

$$G_x[i,j] = \left(I(i,j+1) - I(i,j) + I(i+1,j+1) - I(i+1,j)\right)/2$$

$$G_y[i,j] = \left(I(i,j) - I(i+1,j) + I(i,j+1) - I(i+1,j+1)\right)/2$$

At the moment the direction and magnitude of the gradient（x,y）are:

$$G(i,j) = \sqrt{G_x[i,j]^2 + G_y[i,j]^2}$$

$$\theta[i,j] = tan^{-1}\left(G_y[i,j] / G_x[i,j]\right)$$

3 Gauss algorithm. Its principle is to conduct Gauss fuzzy operation to the image. From the mathematical perspective, that is to do convolution between the normal distribution and image. The normal distribution is also called Gauss distribution, and Gauss fuzzy definition is derived from this. One dimensional normal distribution function:

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, \quad -\infty < \sigma < \infty$$

Two dimensional Gauss surface function definition：

$$g(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}}, \quad -\infty < \sigma < \infty$$

Gauss blur is defined as the convolution between Gauss distribution and the image：

$$L(x,y) = g(x,y) \times l(x,y)$$

L (x, y) is for the blurred image value, and l (x, y) is for the original image value.

Practice has proved that the higher the value of the Gauss radius, the vaguer the picture; the smaller the value, the clearer the picture.

3. 3. Metal Light Performance

In the design of jewelry it needs to draw the picture, and the metal light processing is particularly critical, will influence the entire design effect. Therefore, it needs to use the Photoshop software to carry on the assistance.

3.3.1. Light and shade performance of metal ring: In jewelry design, metal rings are often used, such as the design of the necklace. Although these are available on the Internet by searching for related materials and then stored for use directly, but sometimes it needs to modify the shape and size of ring, in this case the saves material could not be used. So, it needs to master the corresponding drawing method, in order to better design the jewelry products with artistic beauty. The following is a detailed description through the design of metal ring button [5].

 (1) In a drawn picture, the ring buckle in the metal chain is mainly manifested in the front and side. Using this information, we could draw a complete metal chain with straight line drawing tool.

First of all, we deal with the front of the metal ring. Select the "elliptical selection tool" option, at the moment clicking the Shift button, click on the left mouse button, this time a perfect circle selection would be shown in the view. Create a new layer, then click the right mouse button, select "stroke" option and it will pop up a new interface. The stroke width is set as 1 pixels, and the color is white. Click OK. So far, it has drawn the outer surface of the metal ring. The contour line of the inner ring is then produced by the copying option.

 (2) Select the "paint bucket" tool, and fill the metal ring with grey color, then with the same means paint the high light area. Select the "selection", then click "modify", then select "emergence", then pop up a new interface, change the emergence radius value to 3, then fill it with white. As a result, the high light could have the sense of reality.

 (3) Metal's cross line of light and dark and dark section are done through the pen tool, filled with black. Process the scope to be drawn with fuzzy tool, so that light is more close to the real. At this point, the front of the metal ring is successfully drawn.

 (4) Drawing of the side of the metal ring is also finished with the same way. Move to the corresponding place, so that it could be connected with the positive plate. Select the two layers of the metal rings, press the Alt and Shift key, and then click the left mouse button and drag down, so it will produce another metal ring, and further a complete metal chain is completed.

3.3.2 Light and shadow performance of false reverse band: (1) First use the pen tool to depict the outline of the false reverse band, then use the stroke tool to stroke path, then using the "paint bucket" tool to spread a layer of based color on each level. Color of the surface facing light is lighter, and color of the surface back light is darker. In this way, the basic effect of the metal belt is shown [6].

(2) Use the deepening and Dodge tool in the toolbar to smear gray area. Under the condition of having an imaginary light source, the surface facing the light is brightened and the surface of back light is deepened, and the three surfaces of the light, the gray and the dark of the false reverse band is displayed. At the turning place the brightness contrast should be obvious. In this way, the metal texture of the false back is roughly show out.

 (3) The next operation is the modification of the details, and the rendering process and sketch map are the same. After adjustment of source, as long as the dark side, bright surface, gray surface, reflective and cross line of light and dark are drawn, 3D visual of the objects naturally appear. Also we should pay attention to the effect of near real and far virtual, because it determines the sense of space of the object. So when drawing the edge of the bond turning, it should not only pay attention to the thickness of the metal, but also improve the contrast of dark and bright surface. In this way, the space sense and stereoscopic sense of the false reverse can be shown perfectly.

4. Realization of Computer Aided Technology in Jewelry Design

4.1. The Main Application Method of Computer Aided Design Technology

This paper considers that the basic ideas and methods of 3D CAD modeling mainly include that first draw 2D curve required for 3D modeling, including guide, section and contour line; then use appropriate modeling tools to generate 3D structure; according to the requirements of the product style do editing and local effect processing; after model shape, size, structure and hierarchy is determined edit the corresponding material; according to requirements output data for different application purposes[7], as shown in figure 4.

Figure 4. Main Application Method of Computer Aided Design Technology
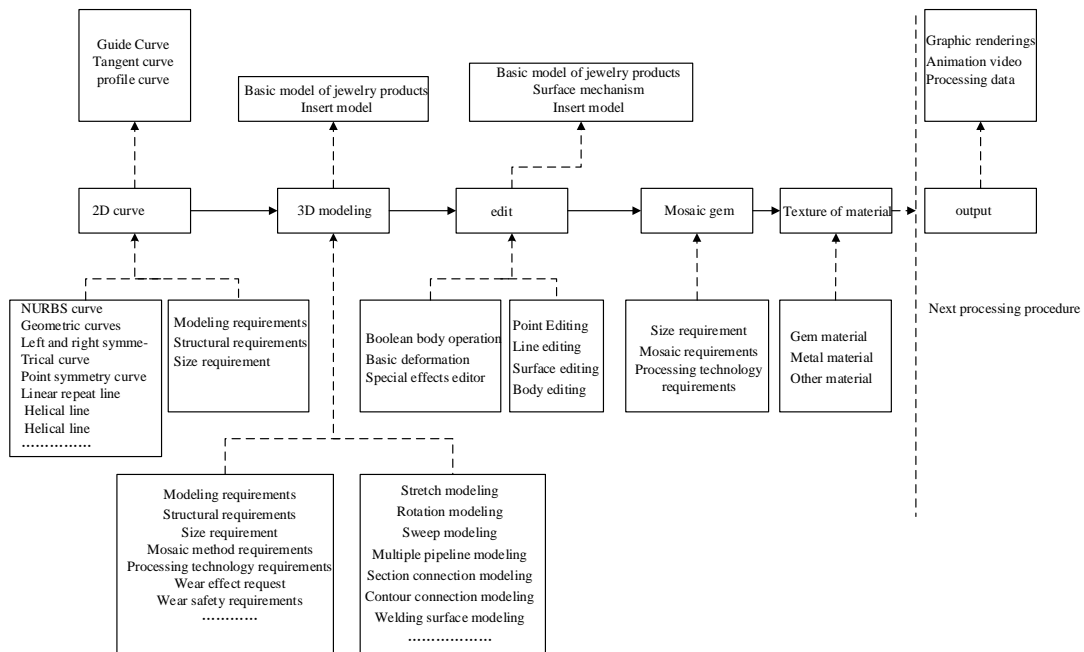
4.2. The Key Technical Parameters of Jewelry in Computer Aided Design Modeling

(1) Basic shape and structure of jewelry. Different styles have different basic modeling and structural characteristics, taking the female ring as an example, in addition to the shape of the ring arm is different, there are differences in surface forms, as shown in figure 5.
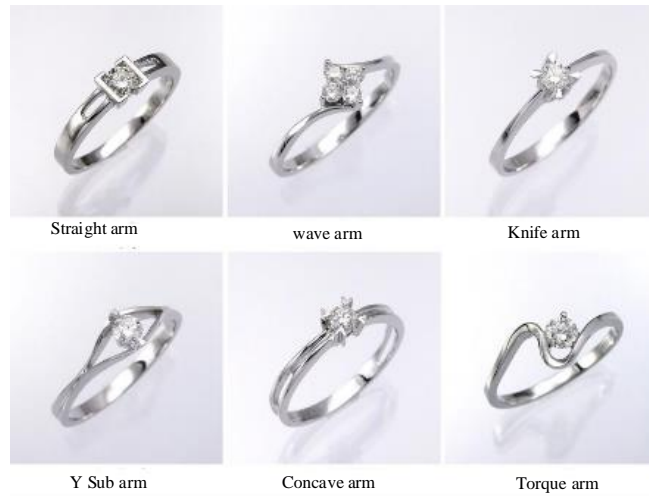
Figure 5. Basic Shape of Part of Female Ring

(2) Size technical parameters commonly used. The sizes commonly used in jewelry production and processing include template processing requirements size (taking the female ring as an example, as shown in Table 1, 2), ring hand parameters (China mainland uses Hong Kong standards for reference, which is usually referred to as the circle number, as shown in Table 3), different types of gem sizes (as shown in Table 4), insert size.

Table 1. Reference of the Related Parameters of Circle Arm Female Ring-1

circle arm female ring (general)				
Gem size (ct)	Width of Silver model (mm)	Width of resin model (mm)	Width of Silver model (mm)	Width of resin model (mm)
0.07	2.1	2.25	1.1	1.2
0.1	2.2	2.35	1.15	1.25
0.15	2.25	2.4	1.15	1.25
0.2	2.3	2.45	1.2	1.3
0.25	2.35	2.5	1.2	1.3
0.3	2.4	2.55	1.25	1.35
0.35	2.45	2.6	1.25	1.35
0.4	2.5	2.65	1.3	1.4
0.5	2.55	2.75	1.3	1.45
1.0	2.8	3.0	1.4	1.55

Table 2. Reference of the Related Parameters of Circle Arm Female Ring-2

circle arm female ring (Slightly thick)				
Gem size (ct)	Width of Silver model (mm)	Width of resin model (mm)	Width of Silver model (mm)	Width of resin model (mm)
0.07	2.2	2.35	1.5	1.25
0.1	2.3	2.45	1.2	1.3
0.15	2.4	2.55	1.2	1.3

0.2	2.45	2.6	1.25	1.35
0.25	2.45	2.6	1.25	1.35
0.3	2.5	2.65	1.3	1.4
0.35	2.5	2.65	1.3	1.4
0.4	2.6	2.7	1.35	1.45
0.5	2.7	2.95	1.4	1.55
1.0	3.0	3.2	1.5	1.65

Table 3. Ring Hand Parameters and Comparison of American and Hong Kong Standards

Hand size（American standards）	Diameter (mm)	Hand size（Hong Kong standards）	Diameter (mm)
0	11.5	1	12.1
0.5	12	2	12.6
1	12	3	13
1.5	13	4	13.3
2	13.2	5	13.6
2.5	13.5	6	14
3	14	7	14.3
3.5	14.3	8	14.7
4	14.8	9	15
4.5	15.2	10	15.4
5	15.6	11	15.7
5.5	16	12	16
6	16.5	13	16.4
6.5	16.9	14	16.8
7	17.3	15	17.1
7.5	17.7	16	17.5
8	18.1	17	17.8
8.5	18.5	18	18.1
9	18.9	19	18.5
9.5	19.2	20	18.9
10	19.6	21	19.2
10.5	20	22	19.6
11	20.5	23	20
11.5	20.9	24	20.3
12	21.3	25	20.6
12.5	21.7	26	21
13	22.1	27	21.3
		28	21.7
		29	22.1
		30	22.4
		31	22.8
		32	23.1
		33	23.4

Table 4. Comparison of Size and Weight of Sapphire, Ruby and Emerald

Size(mm)	Sapphire	Ruby	Emerald
1.4	0.02	0.02	0.01 1/2
1.5	0.0225	0.025	0.0175
1.6	0.02 1/2	0.02 1/2	0.02+
1.7	0.0325	0.0325	0.025
1.8	0.04	0.04	0.03
1.9	0.0475	0.045	0.035
2.0	0.05 1/2	0.05	0.04
2.1	0.0625	0.055	0.045
2.2	0.07	0.06	0.05
2.3	0.08	0.07	0.058
2.4	0.09	0.08	0.06 1/2
2.5	0.1025	0.095	0.073
2.6	0.11 1/2	0.10 1/2	0.08
2.7		0.1175	0.09
2.8	0.14	0.13	0.10
2.9	0.155	0.14	0.106
3.0	0.17	0.15	0.12 1/2
3.1		0.165	0.138
3.2	0.20	0.18 1/2	0.15
3.3	0.22	0.203	0.16
3.4	0.24	0.22	0.17
3.5	0.255	0.235	0.185
3.6	0.27	0.25	0.20
3.7	0.29	0.27	0.21
3.8	0.31	0.29	0.22
3.9	0.335	0.31	0.235
4.0	0.36	0.33	0.25
4.1	0.385	0.355	0.265
4.2	0.41	0.38	0.28
4.3	0.44	0.41	0.30
4.4	0.47	0.44	0.32
4.5	0.50	0.47	0.345

Notes: size unit: mm; weight unit: ct

4.3. Effect of Computer Aided Design Software

The implementation software used in this paper is Matrix. Because of the powerful modeling capabilities, rich gem and material resources and simulation results, Matrix is used by a lot of jewelry designers in the industry, but not as widely as Jewel CAD. The operation interface and related tools are shown in Figure 6. According to the application procedure of computer aided design method, namely 2D curve - 3D model - editing - insert gems - material, the application and effect of Matrix is mainly manifested as the flow chart in Figure 7 [8].
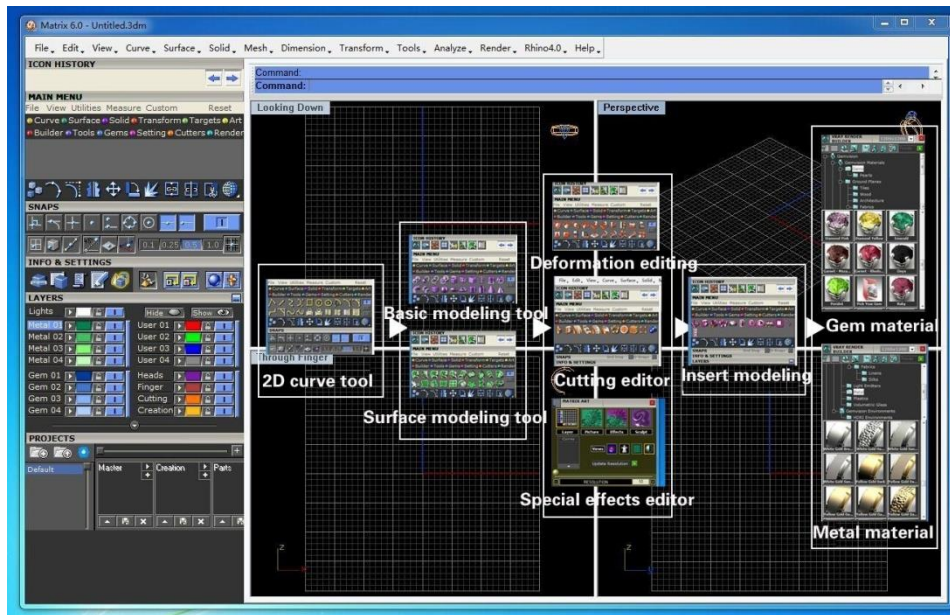
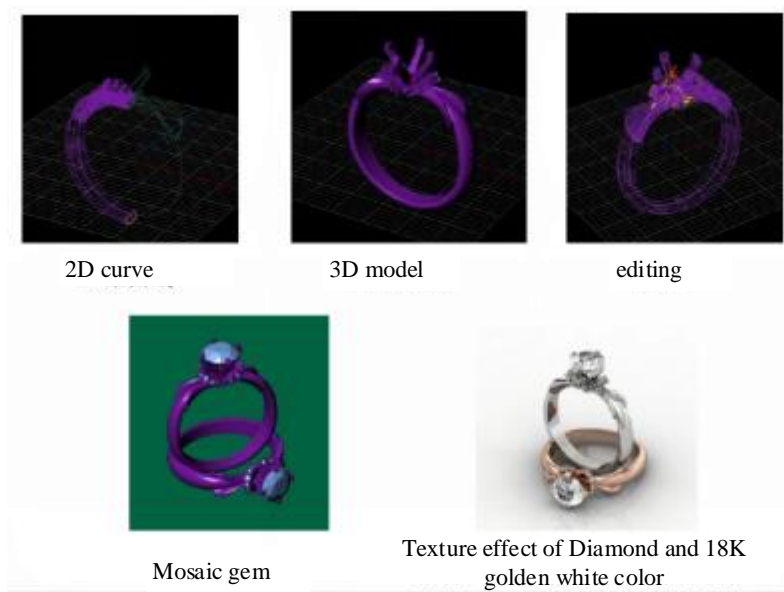**Figure 6. Operation Surface and Related Tool of Matrix**

2D curve   3D model   editing

Mosaic gem   Texture effect of Diamond and 18K golden white color

Figure 7. Modeling Flow Chart and Application Method of Matrix

4.4. Rapid Prototyping

The application process of computer technology is divided into the data output of pre-process model, data input, layout, processing file output, rapid prototyping and post-processing of the model, as shown in figure 8.
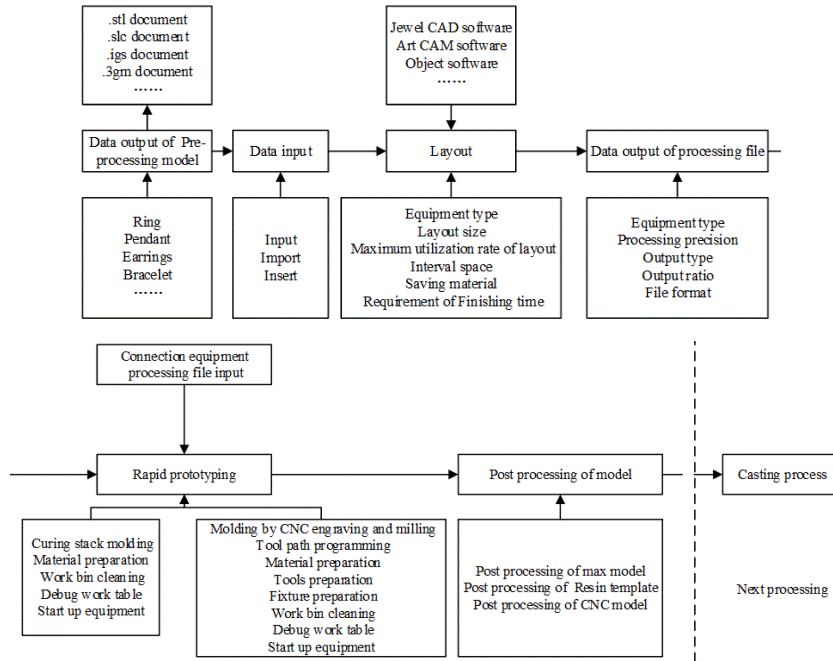
Figure 8. Application Process of Computer Aided Design Technology in Rapid Prototyping

Due to the difference in the used molding material, shrink ratio is also different, and it is necessary to do the corresponding overall amplification processing to the jewelry model before file output, and related technical parameters is shown in table 5. Generally the equipment developed in the nearly two years would try to avoid the problem of shrinking. Developers conduct improvement in plate materials in order to meet the needs of production [9].

Table 5. Relevant Technical Parameters of Commonly used Rapid Prototyping Equipment

`	Equipment name	Maximum machining size (X×Y×Z)	Maximum machining precision (mm)	Compatible file format	Molding material	Shrink ratio (%)
1	3D systems PROJECT CPX3000	152.4×178.31 ×149.61	0.016	slc/stl	wax	0
2	3D systems PROJECT HD 3000	298×185×203	0.025	slc/stl	resin	0
3	Solidscpe T76	152×152×101	0.0127	slc/stl	resin	-0..2%
4	DW028	65×65×90	0.01	stl	resin	-0.02%
5	Envision Tec Perfactory	150×80×300	0.01	Proe/iges/stl/step	wax	0
6	OBJET 250	250×250×200	0.016	stl	resin	0
7	CNC	Different models are not the same	0.01-0.02	3dm/stl	wax、noble metal and so on	0

4.5. Design Sample Results

This paper uses wax template and CPX3000 equipment to produce stencil and the operating method is that use heater to heat the working plate from the bottom (aluminum), control the temperature within 40-46 0C. When the bottom of the stencil begins to melt, remove the stencil and put it on the table for use; method for taking template of engraving and milling shaping template is to open the fixture, if there are supporting points or connection points, use the knife and remove them. After obtaining the stencil, through washing and drying process of wax, we can get the final sample, as shown in Figure 9.
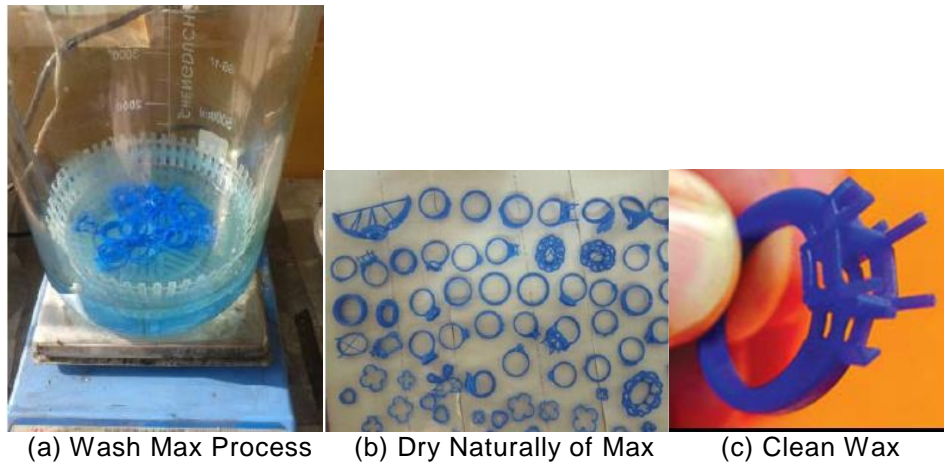

(a) Wash Max Process　　(b) Dry Naturally of Max　　(c) Clean Wax

Figure 9. Post Processing of Wax and Final Sample Display

5. Conclusions

This paper designs a production model of synchronization and diversification which takes computer aided design technology and rapid prototyping technology as the core and it is tested through practical cases. This paper considers that the production model is workable, forward-looking and advanced, and could create value for society and the enterprise and be used as a kind of production mode of the jewelry industry and similar products processing enterprises in the future for a period of time.

References

[1]   B. O. Akinnuli, S. Ayodeji, Computer Aided Design for Cocoa Beans Processing Yield Prediction. International Journal of Applied, 2014, 4(5),pp.12-15.
[2]   Computer vision technology for food quality evaluation. Academic Press, 2016.
[3]   K. Yamashita, K. Arakawa. Interactive color scheme method for visually handicapped people considering design property. 2015 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS). IEEE, 2015: 79-83
[4]   Color and design. A&C Black, 2013, pp.23-26.
[5]   H.Franke, Computer graphics-computer art. Springer Science & Business Media, 2012.
[6]   G. Dalkas, Vlachakis D, Tsagkrasoulis D, et al. State-of-the-art technology in modern computer-aided drug design. Briefings in bioinformatics, 2012, pp.63-65.
[7]   J. E. Swain, D. Lai, Takayama S, et al. Thinking big by thinking small: application of microfluidic technology to improve ART. Lab on a Chip, 2013, 13(7): pp.1213-1224.
[8]   P. Jalas, J. Ruottinen, S. Hemminki, XRF analysis of jewelry using fully standardless fundamental parameter approach. Gold technology, 2002, pp.28-30.
[9]   J. Fischer, Deciduous teeth matrix jewelry and method of manufacture: U.S. Patent 8,661,849. 2014, pp.3-4.